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Concept Designing of Armoured Fighting Vehicles for Future Combat

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ABSTRACT

The experience of military conflicts in recent decades shows changes in the nature of warfare performance, which differ significantly from those conditions for which existing types of armoured fighting vehicles were created. The conducted analysis of the works on the designing of advanced armoured fighting vehicles shows that these changes have not yet been sufficiently taken into account. It still focuses on the creation of high-value combat vehicles with high combat performance for direct (contact) actions. Given the limited economic opportunities of the most countries this inevitably leads to unreasonable expenses. This article presents a conceptual approach to design up to date of armoured fighting vehicles which is based on the asymmetrical principle of their development. Given that the practical implementation of the proposed approach is complex and high-cost, the results of simulation modelling of typical situations of combat use of the offered types of armoured fighting vehicles are given as evidence.

Keywords: Armoured fighting vehicle; Combat application; Asymmetrical development; Technical characteristics; Simulation modelling

1. INTRODUCTION

The experience of military conflicts over the past decades has shown that armoured fighting vehicles (AVFs) continue to play an important role in solving a wide range of combat missions assigned to units of the Army. A tank, an infantry fighting vehicle (IFV) and an armoured personnel carrier (APC) are considered to be the main AFVs types.

Almost all the above types of AFVs were designed in the last century for particular warfare performance. These conditions were defined by different military and political views on conducting an armed struggle, the level of development of armaments and military equipment, scientific, technical, productive-economic opportunities of the opposing force. Since the creation and till present days there is a constant improvement of these AFV types[1,2], however, in general functional purpose of their hasn't practically been changed.

Widespread application of achievements in the military sphere within information technology has led to a significant efficiency increase in the modern weapons systems and the nature of the warfare performance[3,4]. A significant increase in the range, velocity, accuracy and selectivity of the influence of modern armed systems led to the expansion of spatial, reduction of time indicators for solving problems and revealed the need for small units (battle groups)[5].

The main changes of the conditions of AVFs combat application are:

- Significant increase of the possibilities of AVFs' means of destruction[6]
- An increase in the number of diverse goals, changes in the hit distribution law for firing angle[7]
- The transition from the linear interaction of large army units that are operating at operational range of weapons and move towards to destruct the enemy, to the spatial interaction of autonomous combat groups, which simultaneously conduct reconnaissance-shock, mainly non-contact actions in various directions[8].

Modified conditions of combat application put forward new requirements for AFV[9,10]. They include:

- Adaptability to highly maneuverable autonomous actions as part of distributed small units (battle groups)[11]
- The possibility of destroying the enemy's objects outside the line of direct visibility[12]
- The possibility of changing the configuration of armoured vehicles in groups and the indicators of their combat qualities depending on the nature of the tasks which are being solved
- The informational interaction between the group of combat vehicles to provide a decentralised performance of the tasks.

The experience of military use of existing AFVs types in military conflicts, in particular, in Chechnya[13], The Iraq war[14], the war in Syria[15], military operations in eastern Ukraine[16], indicates the discrepancy of their low level of combat effectiveness according to the requirements, which mainly focuses on insufficient protection of the landings and crew, limited fire capabilities, information and functional diversity, inappropriate real conditions of the methods of combat use.

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2. PRELIMINARY INFORMATION

Existing today, a significant imbalance in the development of means of AFVs' protection and means of their destruction, constant improvement, mass character and variability of the ones makes it impossible to create an absolutely well-protected AFV sample. An example of unsuccessful attempts to create a highly secure AFV sample is US Ground combat vehicle[17] program.

Therefore, today it is meaningless to focus only on designing an AFV for a direct (contact) action. To reduce the losses under the conditions of today's armed struggle is important to strike enemy's objects at a long distance without entering the hitting area of its means.

Thus, the main difference between the strategy of conducting modern combat operations from the strategy of the twentieth century is the priority of conducting indirect actions. Changes in the nature of the warfare performance are advance also requests of priority in mobility over the protection of the AFVs which are operating in direct fire contact with the enemy.

Characteristic features of modern warfare performance which, directly influence the development of advanced AFVs types, are:

- Optional to implement of the parameters' high values of combat characteristics in one sample, which usually increases its complexity and cost. The expediency of distributing military tasks between different spatially dispersed means (intelligence, management, destruction) in order to create a network of information of interacting means that make up the combat system. On the one hand this explains the contradiction between the need to solve combat tasks with significantly expanded spatial indicators and it shows economic expediency concentration and application in large areas of high-value specimens.
- Abstraction from the platform features. This means that warfare performance is possible with arms and military equipment, placed on various not necessarily specialised, complex, expensive platforms, the successful operation of which involves the presence of a special providing infrastructure[18].

Thus, the armed struggle moved from the level of confrontation of individual samples to the confrontation of combat systems. The times when the emergence of a separate type of AFVs could seriously influence the effectiveness of the employment of troops, such as the emergence of a tank in the First World War, has been irrevocably passed.

Accordingly, the result of the design should be an AFV system, not a development (upgrading) of separate types of AFV that are unrelated to each other according to the tasks to be solved.

Thus, the modern conditions of combat use of AFV show a completely different way of AFV development. It is in the transition to a massive creation of less universal in terms of combat characteristics and therefore essentially cheaper type of AFV, focused on the network (system) application.

At the same time, the principle is based on the existing approaches to create a promising types of AFV symmetric development, which involves a comparative assessment of relatives of the same purpose or of the same type samples and the creation of already existing analogues [19]. This is the level of confrontation of individual samples. In other words – there is an evolutionary development of existing types of AFV, created for completely different conditions of conducting armed struggle. But attempts to simultaneously implement high military performance indicators one of the existing types, which are already on the verge of exhausting constructive reserves, leads to the emergence of serious problems, that include: an increase in overall dimensions, mass and complexity of samples; high cost; protection problems; long designing terms and recovery[20]. In the conditions of limited economic opportunities of many states, this is inevitably leads to unreasonable costs and lag.

These circumstances require solving a difficult problem, which is to raise the level combat effectiveness of the AFVs taking into an account economic possibilities of the states.

3. PROPOSED CONCEPT

Concerning an alternative approach in designing modern and advanced AFV types, a concept based on the principle of their asymmetric development is suggested in this article as shown in Fig. 1.

Within the framework of the adopted concept, the approach, which is proposed for the technical hypotheses design of perspective AFV types, is determined that simultaneously with the development of technologically complex types, other less costly types of technologically simplified execution are being developed.

In this case, the overall modular design principle, which consists in the AFV design as a set of two independent modules - basic and functional (combat), it is suggested for types of AFV of the technologically simplified performance, as well as for more complex types. In the base module has a control unit, a power plant, transmission elements, a chassis, an important security components, also the necessary connection points with the combat module. Combat module contains a

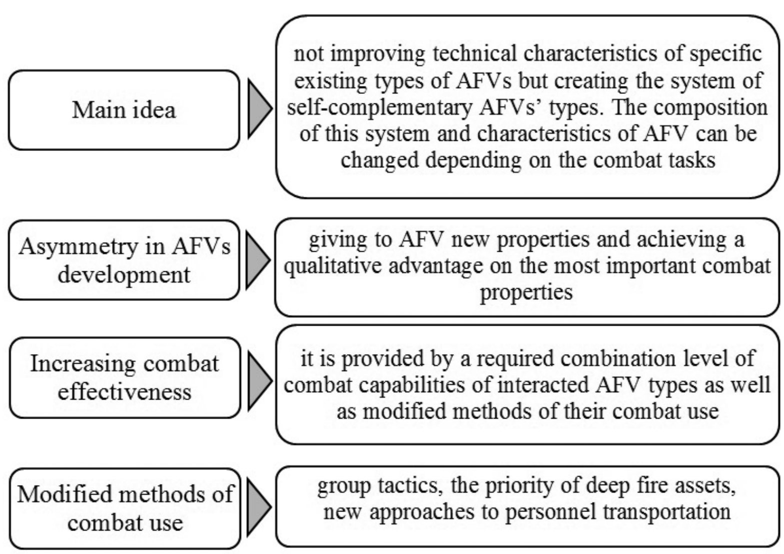

Figure 1. The concept for perspective AFV formation.

complex of weapons, which is carried out outside the body of the vehicle. For the AFV with heavy weaponry the combat module is in an independent case that takes into account the specificity of the weapon. Further choice of AFV technical characteristics is carried out within the limits of the specified design hypotheses.

Sharp rise in the possibilities of modern means of defeat, on one hand, and the need to reduce the losses of the personnel of mechanised units, on the other hand, requires the exclusion of direct fire contact with the enemy, increase its security, expansion of fire capabilities, increasing the mobility and maneuverability to reduce the damage possibility, as well as autonomous security action in the combat groups. There is a need to design a new type of AFV for increasing the effectiveness of mechanised units. As an example of such type is a lightweight combat wheeled vehicle (LCWV) is offered, the conceptual construction of which is shown in Fig. 2. The main idea of its creation and combat application is to prevent total mechanised staff units' localisation in one a combat vehicle (as in IFV, APC) and its spacious distribution into separate AFV ones of a high mobility.

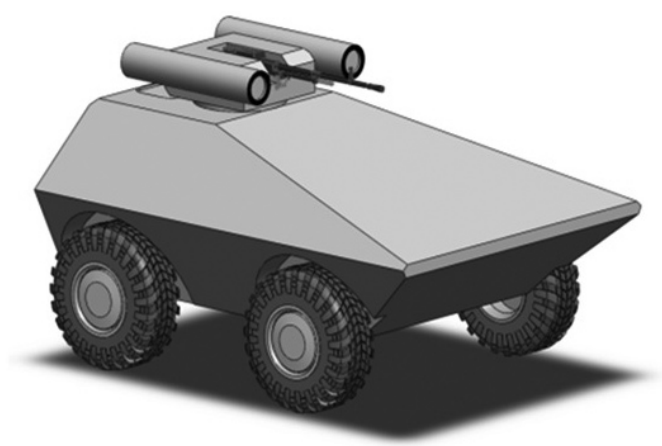

Figure 2. LCWV conceptual construction.

LCWV fulfills its purpose in solving intelligence tasks, fire support, target designation, control in the group of combat vehicles. It can be used to solve tasks in peacekeeping, special operations, stabilisation and specific actions.

Combat LCWV weight – isn't more than 5000 kg, crew - 2 people (a driver, a shooter) or without a crew. Overall measurements: length - not more than 3,9 m, width - not more than 2,1 m, height (without a combat module) - not more than 1,8 m. Armament complex - unified combat modules are remotely controlled. Possible Arms: 12.7 mm (7.62 mm) machine gun, anti-tank grenade launchers, anti-tank guided missiles (ATGM), automatic grenade launcher, anti-aircraft rocket systems of near-action.

However to ensure the safety of the crew, the LCWV design was conducted from the inside, from the crew – by analogous with paradigm to the Occupant Centric Survivability[21]. The level of ballistic protection of the crew – from 12.7 mm B-32 armor-bulb bullets are provided spaced armor (capsule – shell/ body) as shown in Fig. 3. Armoured capsule is made without windows only with a rear door and a hatch which is located in the roof. In this case, the visibility of the crew is provided by

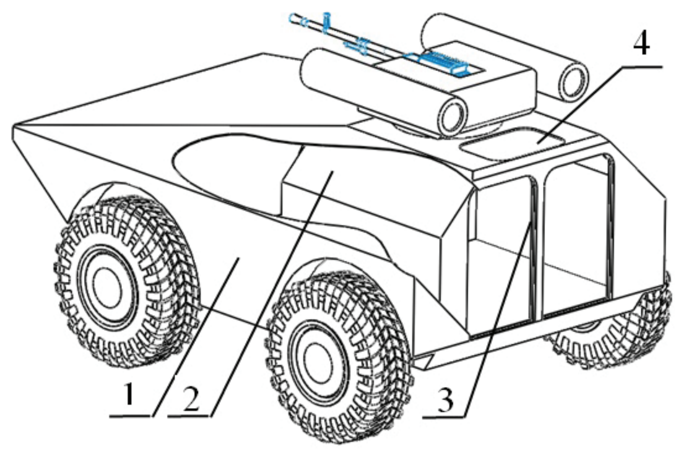

Figure 3. LCWV construction: 1 – shell, 2 – capsule, 3 – door, and 4 – hatch.

the surveillance cameras installed along the perimeter of the combat vehicle.

To addition the main method of LCWV combat use is rapid strikes at previously identified shooting aims. A particular shooting method combined of the dynamic periodical stops, lasting no more than 10 s each at a time. Establishing off-road (horizontal, hollowed, not wet surface) during carrying out of percussive action - not less than 12 m/s. Time of acceleration to the specified velocity - not more than 5 s.

The advantages of LCWV over APC are :

- the reduction of the kill probability of personal of mechanised units due to its spatial distribution, as well as high mobility, maneuverability and protection provided by the combat vehicle;
- expansion fire capabilities by increasing the number of target channels and using more powerful armament mounted on a combat vehicle;
- ensuring the autonomy of subdivisions (combat groups) in various directions due to increased ammunition, fuel supplies that is carried on combat vehicles;
- ensuring the flexibility of the units for prompt response to changes in the situation due to changes in the number of cars which are in the group and their characteristics (composition of armament) depending on the nature of the tasks are being solved.

LCWV is a high mobility combat vehicle with small overall dimensions and weight capabilities. These characteristics at the current level of development of technological capabilities are not allowed to provide the level of protection of the crew from bullets (shells) of a caliber more than 12.7 mm, as well-equipped with more powerful weapons. There is a need to design a combat vehicle intended for fire support by LCWV and the personnel of mechanised units, as well and also to defeat enemy's objects outside the line of sight. The fire support vehicle (FSV) is offered as a combat weapon as shown in Fig. 4. Idea of the creation and combat application of which is to refuse from the concentration of mechanised personnel units in one combat vehicle and use the resulting mass and volume reserve for expansion opportunities concerning: the placement of weapons (ammunition), increase the level of protection,

Table 1. LCWV advantages over APC

AFV type	APC (BTR-4E)		LCWV
Approximate cost, dollars	1 200 000[22]		7 x 170000
Ratio		1:7	
Number of personal	10		2x7=14
Number of target channels	1		7
Projections protection level	frontal – 12,7 mm B-32 lateral – 7,62 mm B-32		frontal, lateral – 12,7 mm B-32

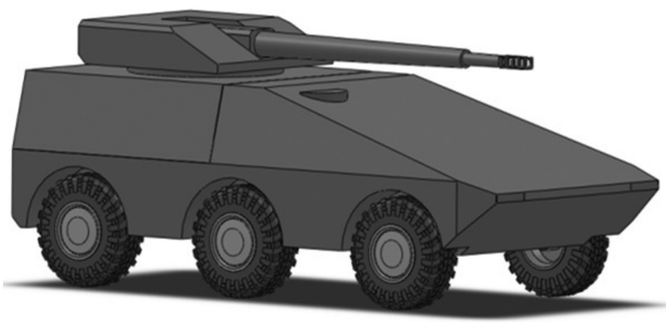

Figure 4. The conceptual view of FSV.

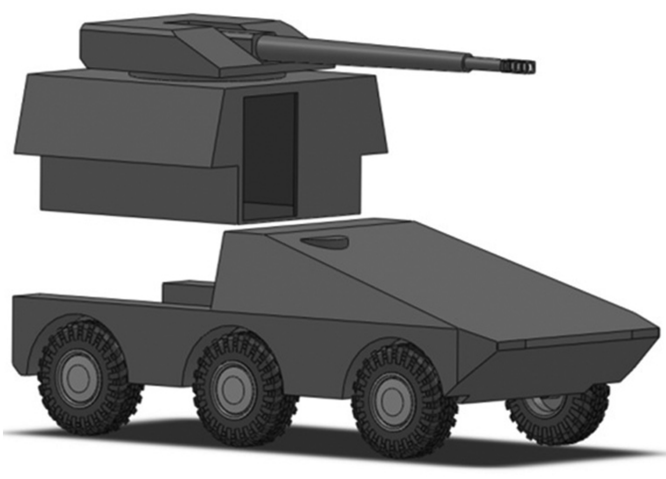

Figure 5. Modular layout of FSV.

ensure the autonomy of action. FSV is capable of accepting external targeting, has modular arrangement as shown in Fig. 5 and depending on the zone of action, FSV can have different weapons, combat weight, wheeled or tracked.

The main weapon for direct fire fighting vehicles support is a automatic cannon with a caliber not less than 30 mm., for military vehicles of long-range fire support - artillery systems of large caliber, heavy ATGM.

Given concepts allowed the formation of the AFV system as shown in Fig. 6. Organisation of combat actions proposed by the types of AFV in the combat group can be represented as follows. In the zone of direct collision with the enemy (up to 6000 m) in a distributed attack reconnaissance and shock actions are carried out with the LCWV. Their fire support is carried out by fighting vehicles of direct fire support, which operate remotely from the LCWV in this zone, as well as fighting long-range fire support vehicles which are operating in the long-range fire zone.

The proposed AFV system provides for the constant exchange of information among all combat vehicles and UAV, which is conventionally indicated by the arrows in the Fig. 6.

The information exchange will provide an opportunity to support decision-making process for unit commanders and for AFVs in a fast-paced tactical environment due to: awareness of the current situation about their own location, positions of their units and neighbors, placement of enemy facilities; the receipt of external targets by the commanders of the FSV for prompt response, the organisation of fire, observation and coordination of actions in real time.

4. EVALUATING EFFICIENCY

Several possible options of their technical characteristics have been identified for assessing the combat effectiveness of the proposed types of AFV as shown in Table 2. Each of these variants consists of basic vehicles and modifications.

Basic vehicles's samples are determined by the number of most needed vehicles for the future. Modifications are created according to a specific purpose, and also taking into account the fulfillment of protection requirements. The ability to create modifications within a specific type and choose the number of families is determined by the analysis of existing unified AFV families.

The assessment of the combat effectiveness of the proposed variants is carried out in their application of typical combat situations using the JCATS (Joint Conflict and Tactical Simulation)[23].

Simultaneously, the following situations were taken into the consideration:

- a counterattack of the combat group of the proposed types

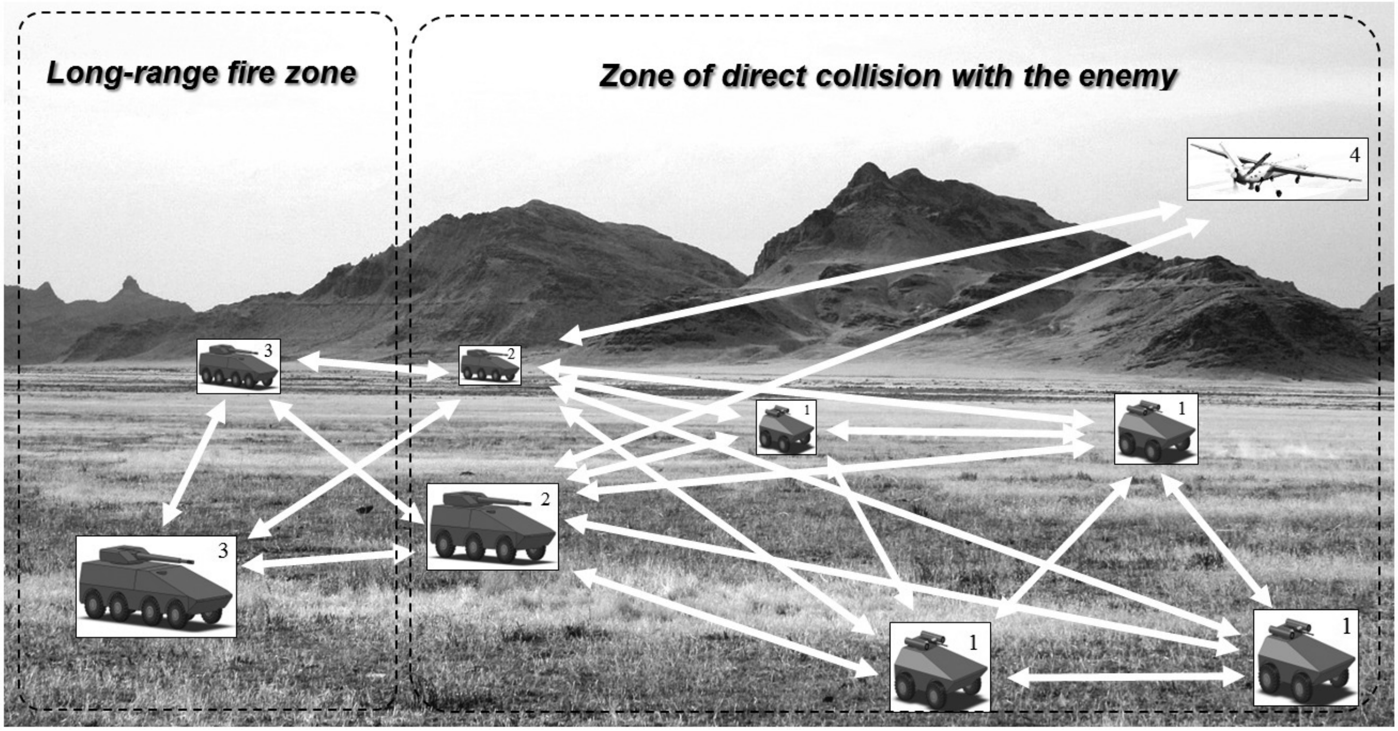

Figure 6. The system of armoured fighting vehicles: 1- LCWV, 2 - direct fire fighting vehicles support, 3 - fighting vehicles of long-range fire support, and 4 - unmanned aerial vehicle (UAV).

Table 2. Possible variants of technical characteristics AFV

Type AFV		LCWV					Fire support vehicle					
						Wheeled					Tracked	
						1 variant						
Payload, kg	Basic	200					5500			9000		11500
	Modifications		400			4000			7000		10000	
						2 variant						
	Basic		400		2500			6000		9000		11500
	Modifications	200		1300			5500					
						3 variant						
	Basic	200				4000			7000			11500
	Modifications		400		2500			6000				
						4 variant						
	Basic	200				4000				9000	10000	
	Modifications		400		2500		5500		7000			11500

of AFV against a mechanised company on IFV, reinforced with the tank platoon;

- the elimination of illegal armed formation in the ambush during escort operations;
- elimination of illegal armed formation of combat groups of the proposed types of AFV during an armed conflict on state border.

The criterion of combat effectiveness of the AFVs is to provide the minimum losses on a required level of combat effectiveness.

Further analysis of the constructed simulation models is carried out by means of determination of dependencies the indicator of combat effectiveness (losses of AFV) from the armament structure, overall dimensions, combat methods

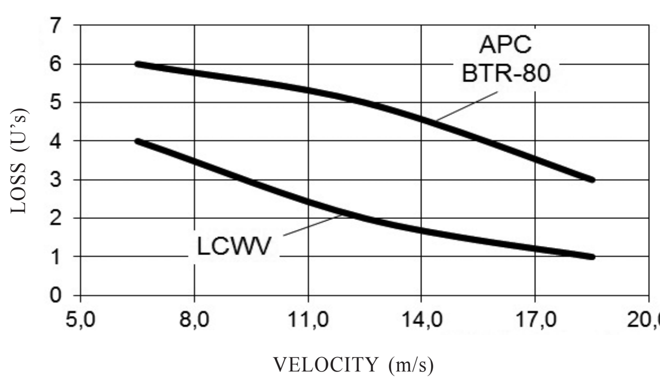

Figure 7. AFV loss dependency on velocity.

application (velocity, attack formation, shooting method.).

Figure 7 shows the dependences of the losses of BTR-80 and LCWV on their velocity during the liquidation of an illegal armed formation (IAF) in ambush. Modelling conditions: relief - hills up to 400 m high; season - summer; weather conditions - dry, sunny day; the soil road; number of AFV - 7 units; distance between vehicles 25-30 m; IAF - 10 people, located at the turn on both sides of the road (5 people) at a distance of 150-200 m from the road; height at road level - 10-15 m, distance between shooters - 10-15 m, armament: machine gun 12.7 mm - 2 units, RPG-7 - 3 units, AK-74 - 5 units.

Simulation using JCATS simulation system was performed under the same conditions for both BTR-80 and LCWV. Only the velocity of movement in the column is being changed. As a result, it was found that the amount of losses (losses in units) of the BTR-80 exceeds the losses of LCWV by 33%.

Figure 8 shows the dependences of the losses of the proposed types of AFV on the composition of the armament complex during the liquidation of the IAF at the state border. Modelling conditions: terrain - plain, steppe; time of year - summer, weather conditions - dry, sunny day; the nature of the soil surface - virgin land; number of AFV - 6 units. in each group (LCWV - 4 units, FSV - 2 units), the number of groups - 4; distance between groups - 1000 m, fighting order - loose, in front of LCWV, behind at a distance of 250-300 m - FSV; distance between LCWV - 150-200 m; velocity of movement - 15-20 km / h; LCWV armament - 12.7 mm machine gun; armament of BMVP: main - automatic cannon, 105 mm cannon, additional - 7.62 mm PKT, ATGM; total: AFV - 24 units, personnel - 48 people; number of IAF - 34 people. in the group; number of groups - 3; distance between groups - 1000 m; fighting order - scattered; armament: 12.7 mm machine gun on all-wheel drive cars - 6 units, RPG-7 - 10 units, PKM - 10 units, the rest - AK-74; total: cars - 6 units, personnel - 102 people.

According to the results of the assessment of the combat effectiveness of each of the possible variants and the comparison of obtained values with the level of combat effectiveness of existing AFV, next variants were selected as the indicator of values of combat effectiveness which exceeds the corresponding values of existing AFV. The procurement costs and combat use were determined at the next stage as shown in Table 3 for each of the selected variants, as well as for existing AFVs. Comparing the obtained values, given variants which provide solving the combat missions with smaller loss in comparison with existing AFV costs, were determined. On the last stage the most rational one was determined among these variants. This is an variant where the number of the personnel that is involved in the solution of the combat missions is the smallest one.

The results of the conducted research has shown in Table 3, that the third variant is rational.

The proposed version consists of four basic vehicles and three modifications. Basic vehicle with a payload of 200 kg and a maximum combat weight of 4000 kg - LCWV. Its modification with an extended wheelbase with a combat weight of 5000 kg is intended for installation of more powerful combat module. Basic vehicle with a payload of 4000 kg and a maximum combat weight of 12000 kg - fire support vehicle with wheel formula 6x6. Its modification is characterised by a lower payload (2500 kg). Base vehicle with a payload of 7000 kg and a maximum combat weight of 19000 kg - FSV with wheel formula 8x8. Its modification is also characterised by a lower payload (6000 kg). The base vehicle with a payload of 11500 kg is a tracked one, the combat weight of which is 35300 kg.

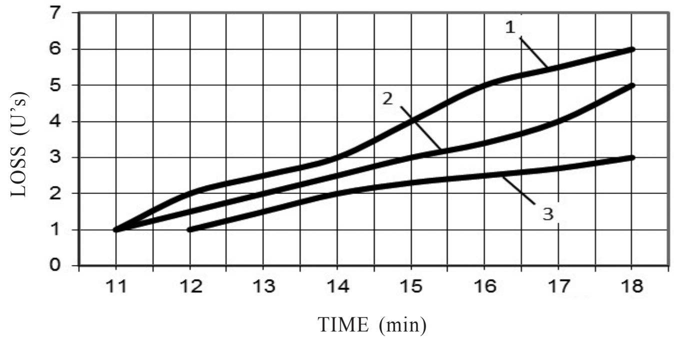

Figure 8. AFV loss dependency on a weapon complex: 1 – 105-mm cannon, 2 – 30-mm automatic cannon with high-explosive shell, and 3 – 40-mm automatic cannon (high-explosive shell with a remote exploder).

Table 3. Evaluation results

Performance indicators	AFVs variant				
	Existing	1	2	3	4
The procurement costs and combat use, MM. hrn.	925,1	865,2	785,1	815,4	960,3
Number of personnel, ppl.	318	108	126	97	149

5. CONCLUSIONS

The peculiar changes in the nature of the warfare performance impose new requirements for the armoured fighting vehicles (AVFs) the implementation of which leads to the emergence of new combinations of combat characteristics and methods of their combat use.

The paper suggests a conceptual approach to the design of advanced AFV types, based on the asymmetrical principle of their development which allows to take into an account the changes in the conditions of combat use and limited economic opportunities of the state.

Within the framework of the proposed approach to increase the effectiveness of combat use of AFVs is provided at the expense of maximising the beneficial use of network application; reduction of overall dimensions, combat weight, destruction probability; modification in proportion in value of the target (AFV) and the cost of its destruction; the involvement of less number of personnel in solving military tasks.

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In the present work, he provided valuable inputs to the author in the research field of current topic and guided it in the modelling, simulation and analysis tasks to obtain the final outputs and organising the research findings.

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His contribution in the current study complemented it in the direction of the information component of the battle.

Halyna Lotfi Ghahrodi, external PhD student, lecturer of Foreign Languages Department, Lviv Polytechnic National University.
Contribution in the current study, she has surveyed worldwide trends in the development of armoured fighting vehicles. She has also edited the manuscript of this paper.